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Contract Number	**NNX09CF65P**
Title	**HPC Benchmark Suite NMx**

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

In the phase II effort, Intelligent Automation Inc., (IAI) and University of Central Florida (UCF) propose to develop a comprehensive numerical test suite for benchmarking current and future high performance computing activities that will include: (1) dense and unsymmetrical matrix problems faced in space aviation and problems in thermally driven structural response and radiation exchange, (2) implicit solution algorithms with production models and benchmarks for indefinite matrices and pathological cases, (3) configurations scaling for large systems in shared, distributed and mixed memory conditions, (4) documentation for strengths, weaknesses, and limitations of the toolkits used together with recommendations and (5) precision and round-off studies on serial and parallel machines, comparison of solutions on serial and parallel hardware with study of wall clock performance with respect to the number of processors

We successfully demonstrated in phase I that we can accurately and precisely benchmark run time solvers of dense complex matrices in hybrid-distributed memory architecture. We achieved highly scalable super-linear speed-up and scalability of the algorithm for large problem sizes. The tools developed in phase II will greatly improve the performance and efficiency to adapt the benchmarks to HPC systems different hardware architectures at NASA facilities and for non-NASA commercial applications.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

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Objective 1: Develop embedded firmware (in the form of IP cores) for side-lobe suppression techniques and DPD for pulse compression radar transceivers, and implement them on the proposed RDP platform.

Objective 2: Refine and implement Doppler and tangential wind velocity estimation techniques on the proposed RDP platform

Objective 3: Design of the RDP platform with low-power FPGAs and co-processors. Emphasis will be on seamless integration with existing radar systems with NASA Goddard, and the use of COTS platforms with minimal custom hardware design.

Objective 4: Enhancement of advanced airborne weather radar simulator design.

Objective 5: Demonstration of real-time processing capabilities for pulse compression radar using the RDP platform and initial integration-commercialization efforts.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

Phase-I technical accomplishments are:

- In the phase I effort, we successfully demonstrated and reported in detail the feasibility of benchmarking using Scalable Linear Algebra PACKage (ScaLAPACK) PZGESV routines for large complex matrices of various densities and sizes. For the proof of concept in the phase I we benchmarked thermal equilibrium solver problems of the form of equations $K * \Delta u = r$, where K is an unsymmetric dense matrix with this solver.
- We obtained super linear speedup and scalability for the dense matrix solver for large degrees of freedom.
- The phase I benchmark for large dense matrices with implicit solution algorithm included: (1) Comparison of solutions on serial and parallel hardware and study of wall clock performance with respect to the number of processors and configurations scaling for large matrix in shared, distributed and mixed memory conditions, (2) Scaled speedup and efficiency benchmark with performance respect to the number of processors, (3) Scaled benchmark for varying matrix densities, and (4) documentation for strengths, weaknesses, and limitations of the toolkits used together with recommendations

NASA Application(s): (Limit 100 words or 1,000 characters, whichever is less)

For NASA there is a vast potential need for benchmarking the solutions that could be applied to heat transfer problems in structures in avionics, diagnostic of structures in space exploration and exploration of structure formation, weather, nuclear simulations and problems in geology. Applications include testing requirements for temperature contour of space shuttle, boundary layer Transition protuberance, heat shield problems computations and computation architectures where simulation modeling environments have solvers that run into hundreds of degrees of freedom. IAI has a long history of successfully developing distributed computing simulation applications for NASA.

Non-NASA Commercial Application(s): (Limit 100 words or 1,000 characters, whichever is less)

Most promising Non- NASA commercial applications are:

High performance applications include thermal and structural problems in industry, manufacturing sectors and military. Other applications include diagnostics, weather, nuclear simulations and health monitoring applications.